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Air Pollution: Can We Control It?
Arthur J. Benline

The Story of The Zero
Bernard F. Pierce

Vol. 46 No. 2

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M. E. McIVER, Editor

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Engineers...

Measure Up To Your Civic Responsibilities

1. Urge the importance of comprehensive planning, in order that needs of the community may be anticipated and relative importance of public improvements clearly understood.
2. Insist upon creation of boards to plan programs of public improvements, replacing uncoordinated projects now directed by legislation.
3. See that registration laws are enforced and that all technological positions are filled by professional engineers.
4. Demand civil service protection of engineering judgment and integrity.
5. Organize in local and state societies, available for counsel on technological matters considered by other civic agencies.
6. Affiliate with Chamber of Commerce in order to cooperate in initiating programs and supporting those sponsored by civic agencies.
7. Open engineering society meetings to the public when community problems are discussed.
8. Help make every dollar of taxpayer's money count for civic efficiency.
9. Be individually alert in observing smaller needs of your community.
10. Remember that every educated citizen bears a responsibility in a democracy to guide public opinion.
11. Establish close relations with service clubs, with the press, in order to fulfill this responsibility.
12. Cultivate the art of describing technological projects and their social and civic significance in terms understandable by the laity.

Air Pollution: Can We Control It?

by
Arthur J. Benline, P.E., R.A.

Commissioner, New York City Department of Air Pollution Control
Member, American Association of Engineers

One of the ways of judging the "success" of an idea, a movement or a product is to note the number and extent of the mentions received in the mass media. Using this yardstick, it seems fairly certain that air pollution control has "arrived."

Newspapers, magazines, radio, television—all are interested in air pollution control, not as a "one-shot" proposition, but as a fairly steady diet. Air pollution control is becoming news and big news almost everywhere. There are two major items that the mass media want to know about most of the time:

1. How much pollution is in the air and what kind is it?
2. Is it damaging our health or even killing us?

The First Question

The first question is not too hard to answer, whenever an air pollution control agency has the facilities to measure the filth in the air. It is not easy, nor perhaps necessary, to say that X per cent of the total pollution is caused by Y, but it is certainly not difficult to say that so much percentage of sulfur dioxide, or carbon monoxide, or other pollutants is in the air we breathe. The statistics are available and we obtain more every minute.

The Second Question

The second question is much harder to answer. We know that air pollution, in extreme cases, can kill people and can make many others ill. We do not know—nor may we ever know—what a "normal" amount of air pollution, day after day, year after year, may be doing to us. Certainly no one can claim that any form of air pollution is good for human beings.

The interest of the mass media reflects a growing awareness on the

part of the public of the problem of air pollution and the need for its control. Of course, this awareness is necessarily limited to that segment of the population which is aware in general of what is going on around them. But, this is the vocal and active segment of the population and the one that has the greatest effect on the path our society takes.

These people have a generally basic question: Is air pollution being controlled as best it can? We might say that at the heart of that question is an even more basic one: Can air pollution be controlled?

The answer is evasive, but truthful: If by controlled is meant eliminated, the answer is, no. If by controlled is meant reduced to an ever smaller amount the answer is, maybe.

There is no such thing as clean air. There may never have been such a phenomenon on the face of the globe. There certainly is not such a phenomenon anywhere today. Civilization, from its most primitive to its most sophisticated form, causes pollution of the air we breathe. It will continue to do so. Air pollution cannot be eliminated entirely. The only way to accomplish that would be to eliminate human beings—a step not yet advocated by even the severest critics of governmental air pollution control agencies.

"Clean Air Costs Money, Dirty Air Costs More"

Air pollution can be reduced and is being reduced wherever the people who ask the questions are willing to pay for such reduction. In the New York City Department of Air Pollution Control, we have a slogan: "Clean Air Costs Money. Dirty Air Costs More." In fact, dirty air, one of the most serious threats to our national resources, according to President Kennedy, is costing the United States about $7,500,000,000 a year. In addition, industry claims it is spending about $500,000,000 a year to combat air pollution. Control agencies are spending about $8,000-000. Add that up and it is a very considerable amount of money, but it is obvious that we are spending far less to control air pollution than air pollution is making us expend in its hidden or obvious ways.

These ways are many. We lose money because of air pollution through wasted fuel and materials which escape into the atmosphere instead of being put to the uses intended. We lose money by damage to buildings, furnishings, livestock, crops. We lose money through loss of sunlight. We lose money through impairment of our good health and there is evidence that some aspects of air pollution will result in loss of life.

This is not to say that we should spend $7,500,000,000 a year to combat a pollution problem which is costing that much. There is no need to do so. But, we should certainly spend more money on controlling air pollution than we are spending and we should try to spend it wisely.

How can it be done? One way is to fight air pollution in every local community before the problem becomes so bad that emergency action must be taken. Emergency action of any kind is never very successful

for long and mistakes may be made at the outset which cannot be rectified for years. It is certain, however, that air pollution should be fought everywhere as quickly as possible, because every area of this country, regardless of size or location, is suffering or will suffer from air pollution.

Air pollution comes from many sources—some or all of which are located everywhere. It comes from consumption of fuel for heat and hot water. It comes from the incineration of refuse. It comes from hundreds of industrial sources. It comes from automotive vehicles.

It is clear that no community is or can be immune.

In every one of these areas—with the qualified exception of automotive vehicles—there are solutions of one sort or another available now. In other words, air pollution can be controlled, to a certain extent, no matter what type it may be or what it may be.

There is just one trouble. The people of the local community must *want* to control air pollution—for a very simple reason: Air pollution is not something which you can attack with vigor in a blaze of civic virtue and pride for a year or so and then retire confident that the dragon will not return. Nothing could be further from the truth.

Air pollution is a by-product of civilization. That means people and the places where they live. That means error or the possibility of error—either intentional error or unwitting error. But, error in any case.

Air pollution, in a sense, is something like the traffic accident problem. The police may have a crackdown on traffic violators one weekend and they may pull in a great many of them and perhaps a great many people are saved from death or injury. But, the police do not disappear then, satisfied that all is well.

All is not well. The human being, by definition, is going to make mistakes. That is why we will have air pollution, no matter how universal the demand for cleaner air may get. And, remember, the demand for cleaner air among the knowledgable and articulate segment of the public represents, unfortunately, only a small fraction of the public at large. Most people live from day to day never knowing or caring about what happens to them, unless, as one columnist put it, something comes up to the table and eats the baby.

The Problem Must Be Faced

It is an unhappy prospect, but it must be faced: There are no magic wands or secret words in the field of air pollution control. This is a long-range, constant battle for the cleanest air possible. It is a battle which will be fought by those who care about the world around them. It will have its setbacks and its triumphs and sometimes it may be difficult to distinguish one from the other.

Can we control air pollution? Yes—but only if we want to and keep wanting to.

The Story Of The Zero

By Bernard F. Pierce

As is the case with so many of the marvels that are in common use in our civilization, the numbers we employ for checking the baseball score or computing the fuel consumption of a three-stage rocket are taken for granted with little appreciation of the human ingenuity that has made them available to us. Of particular interest is that little oval we write as a shorthand symbol for the word "nothing." The zero, often considered the most humble of the ten digits, is by far the most important since it is the one that makes our counting system so much superior to those of the Romans or the Greeks. Were it not for the improved method of numeration that the zero makes possible, it is probable that technologically our civilization could hardly have advanced much further than it was at the end of the Middle Ages.

In order to be able to fully appreciate the value of the zero in our way of counting, the unique role it plays as a number must first be understood. The abacus, used by the ancients for computing and by modern grade school teachers for making the theory of numbers clearer to their students, is the ideal mechanism for demonstrating the function of the zero. In the abacus illustrated in Figure 1 assume that the value of the individual counters progressively increases by a factor of ten for each of the vertical columns in going from right to left. Thus, all the counters in column A have a value of one, those in column B have a value of ten, those in column C have a value of one hundred, and so on. Further assume that a number is indicated by moving counters to the lower end of the frame. Now observe that in Figure 1 there are three counters in column C, meaning 300; there are eight counters in column B, meaning 80; and there are seven counters in column A meaning 7. Put them all together and they mean 387. Now look at Figure 2 and note that an identical amount of counters occurring in the same order as in Figure 1 have been moved to the lower end of the frame, but they are now located in lifferent columns. By knowing the values of the counters in each of the columns it will be seen that the number represented is 30,870. Differentiation between the values of the two numbers indicated in Figures 1 and 2 is dependent on the knowledge of which of the columns are empty. The graphic representation of such empty columns is precisely the role of the zero. It eliminates ambiguity by indentifying which positions in a numeral are meant to be vacant, thus making clear the *positional value* each digit acquires (in addition to its specific "face value") according to its relative position in a number.

However, since the abacus existed many centuries prior to the invention of the zero, it is clear that the concept of positional value was

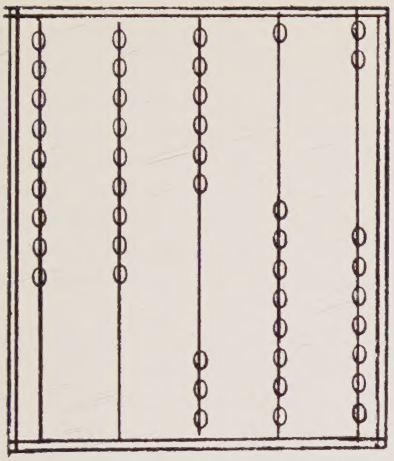

Figure 1

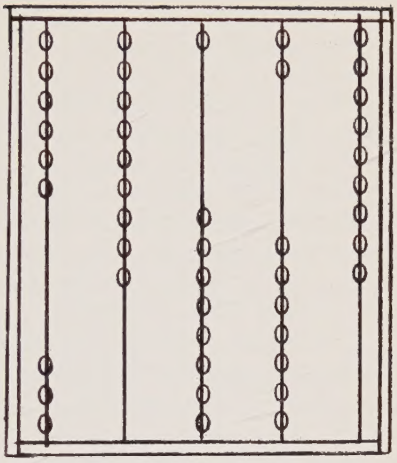

Figure 2

in use long before there was a method of writing it. It is precisely because of this positional-value quality of the abacus that it was utilized for computations by peoples who had zeroless counting systems, which were entirely unsuited for mathematical maneuvering.

Another instance of the use of positional value without the zero occurred among the prehistoric Incas of Peru, who, having no writing whatsoever, kept the records of an empire that numbered more than ten million inhabitants with a system of knotted cords, or *quipus*. A *quipu* normally consisted of a main cord, which was held horizontally and from which were hung numerous other cords in the manner of wash on a clothesline. According to its relative location on the main cord, each of the dangling cords gave the positional value to the knots that were tied in it, and of course, no knot in a cord was analogous to no counter in an abacus column.

However, it was having the technique of a written system with positional value and a symbol for "nothingness" that was to provide mathematics with the tools that were to be essential in the development of modern technology. Various peoples have been able to achieve, but never surpass, a pre-machine civilization without the zero. The mathematical genius of the Greeks was hampered because they lacked this important concept. Their remarkable achievements in geometry were primarily based on relationships that could be perceived and maneuvered in the physical world, but they could never pass the preliminary phases of algebraic abstractions with their primitive method of writing num-

bers. In the numeration of the Greeks the first ten letters of their alphabet represented the numbers from one to ten, and subsequent letters represented the multiples of ten up to a hundred, and the multiples of a hundred up to a thousand, and so on. After all the letters of the alphabet were used up, special symbols had to be invented for the higher numbers. To indicate the number for 387 the three letters that stood respectively for 7, 80, and 300 would be written adjacent to each other with the understanding that it was their sum that was being represented. Observe, however, that the number 30,870 would require an entirely different set of symbols and would be written with the three letters that stood for 70, 800, and 30,000.

The Romans got by with appreciably fewer symbols by individually representing only the integers in the following series: 1, 5, 10, 50, 100, 500, and so on. Of course this resulted in the use of addition to a much greater extent, and in some cases it required a long string of symbols to represent a number such as 387, which looked like this: CCCLXXXVII. Classical Chinese writing has individual symbols only for the numbers one through ten, one hundred, one thousand, and ten thousand. Our 387 would be written with the characters which stand for each of the following numbers in parenthesis: (3)(100)(8)(10)(7). It will be noticed that an incipient form of positional value occurs here, and it should also be mentioned that there is a character which is frequently used to indicate the absence of number characters in the midposition of numbers like 307. However, Chinese numeration lacks that essential criterion of a system that is genuinely based on positional value since it is incapable of representing numbers of indefinitely greater magnitudes without constantly having to employ additional symbols. In our system any number, no matter how great, can be represented by the use of only ten symbols.

The unknown originator of the written symbol for nothing made a contribution to human culture that is considered to be among the greatest mental feats in history. It is therefore curious to consider that this ingenious concept was independently originated among three peoples who were widely separated from each other in both space and time. The ancient Babylonians began employing a symbol for the zero about 500 B.C., but its use apparently died out about 2000 years ago along with the cuneiform script in which it was written. For more than 1500 years before the discovery of America the Mayas of Guatemala and Yucatan had been using a zero which was represented in the form of a shell in their hieroglyphic writing. The zero of modern civilization originated in India about 500 A.D., and the Arabs, who acquired it about three hundred years later, eventually introduced it into Europe through Italy and Spain. Though many Europeans were familiar with the zero by the year 1000 A.D., it was not until the 14th century that its use virtually replaced the traditional Roman numerals. In its travels the symbol representing our zero has undergone modification. Although the num-

bers used in the Western World are referred to as "Arabic," the modern Arab uses a dot to write a zero while his five is represented by the symbol we use for zero.

The etymology of the terms used to designate the zero parallels the history of its migration. The word "zero" is ultimately derived from Sanskrit *sunya*, meaning void, which became modified to *sifr* in Arabic. In the Latin of the European scholars the Arabic word was transliterated into *zephyrum*, which in Italian first evolved into *zepiro* and later into zero, the form which was transmitted via French into English. A different set of mutations occurred in the pronunciation of the Arabic *sifr* as it traveled an alternate route through Spain where it became *cifra*. It then passed through Old French as *cifre* and into English as cipher.

The relationship between the zero and counting by tens is not a necessary one. The long, intimate, and usually exclusive association we have had with the decimal system frequently results in the assumption that the use of a base 10 numbering system exists as some sort of natural phenomenon. The fact that we use ten as a radix in counting is merely the historical result of a very arbitrary choice which, however, was undoubtedly influenced by the fact that there are ten "digits" on the hands. It is remarkable that in each instance of its independent invention the zero was associated with a numerical system having a different radix. The Babylonians had a sexagesimal system (base 60), and the Mayas had a vigesimal system (base 20). Numerical systems having other bases have been devised for special mathematical and scientific purposes. It should be kept in mind, however, that the principle of the zero and positional value were already available to those who were developing such systems. Binary numeration, developed by Leibniz in the 17th century, has been the most important and useful of these special systems. A method of counting which uses a radix of two is readily adaptable to electronic computers in which the presence of a signal represents one, and the absence of a signal represents zero.

To illustrate the function of the zero in each of these four numerical systems, here is a mathematical comparison of what the value in each system would be for a one followed by three zeros:

Decimal:	$1000 = 10^3$
Binary:	$1000 = 2^3$ $(= 8$ in decimal$)$
Vigesimal:	$1000 = 20^3$ $(= 8000$ in decimal$)$
Sexagesimal:	$1000 = 60^3$ $(= 216{,}000$ in decimal$)$

Note To The Editor On Sources

Much of the material presented here comes from general anthropological sources. However, the following three works provided important data on specific subjects:

"From Numbers to Numerals and From Numerals to Computation," in *The World of Mathematics*, James R. Newman, ed., New York, 1956, pp. 451-454—gives some historical material on the Hindu zero.

The Development of Mathematics, E. T. Bell, New York, 1945, p. 31—tells of the Babylonian zero.

The Ancient Maya (3rd Edition, Sylvanus G. Morley and George W. Brainerd, Stanford, California, 1956, pp. 239-241, 428-429—is about the most complete source on the Mayan zero.

For more than 1700 years after the death in 212 B.C. of the Greek mathematician Archimedes no major advances were made in mathematics. Then, during the sixteenth and seventeenth centuries, as if a sudden inspiration had animated the scholars of that time, most of the basic mathematical tools on which modern technology depends were invented. Decimal fractions, negative numbers, exponents, logarithms, and others which now came into being, all depended on the zero and the principle of positional value.

In the case of some of the more obvious primary innovations in human culture, such as agriculture and atomic power, it is clear that they have radically changed the course of man's development. But there are other inventions, such as the zero, that have had just as dramatic an effect on the destiny of world civilization, but because of their more subtle nature their influence is often misunderstood or ignored.

A.A.E. Members at Table No. 9, Mayflower hotel: Walter B. Farrar (standing) Richard M. Bush, Charles W. Palmer, Willis Collins, P. Harry Byerly, Henry Warner Austin, Howell F. Lewis, Jr., Jeremiah Tempone, and Dr. Charles D. Luke.

* * * *

Henry W. Austin was kind enough to send us a photograph of some of the Association's members in attendance at the 55th annual banquet of the Washington Society of Engineers, held in the Mayflower Hotel—Grand Ballroom, Washington, D.C.

The meeting was well attended by members of the Society, and we wish to thank Mr. Austin for his courtesy in seeing that a photograph of the A.A.E. Table was taken and forwarded to National Headquarters.

North Idaho Junior College Student Engineers

Roger James, Spokane Sanitation Engineer, Washington State Department of Health, was guest speaker at one of the monthly dinner lectures of the North Idaho Junior College chapter, American Association of Engineers.

The dinner, held at the Sourdough Club, was a joint meeting of the Idaho State Professional Engineers and the student engineers from the N.I.J.C. in observance of National Engineers' Week.

Mr. James spoke to the group of the water supply problems that municipal and sanitation engineers are confronted with and stressed the importance of water for industry, recreation, and the health of the nation's population. He also pointed out that the sanitation engineer is concerned with the disposal of radio-active and industrial wastes, refuse disposal, and air pollution problems.

Jack F. Pearring, District Engineer, Idaho Department of Highways, spoke of the significance of National Engineers' Week and read a letter sent to the nation's engineers from President Kennedy which stated that more young people should seek careers in the engineering profession. Mr. Pearring concluded his talk with the presentation of a birthday cake to Tom Miller, Idaho Department of Highways, who has been in the engineering profession for the past twenty-five years.

—James A. Kirschner, Secretary

A Tiny Transistor

From "Electronic Age," R.C.A., summer number, we note the following interesting piece of information:

An ultraminiature experimental transistor, so tiny that as many as 20,000 can fit on a postage stamp has been tested successfully at RCA Laboratories.

The transistor is made by depositing thin films by evaporation on an insulating base and is capable of shrinking the basic circuitry of a computer to the size of a book page. The basic circuitry of present-day computers ranges in size from the equivalent of a large hat box to a walk-in closet.

It is believed that this is the first time that transistors having useful performances have been produced entirely by the thin-film technique of evaporating all materials upon an insulating base—in this case, a glass plate.

Emphasizing the precision of the techniques, Dr. James Hillier, Vice President, RCA Laboratories, points out that a complete three-stage amplifier including thin-film transistors and their connections could be produced this way on a surface only twice as wide as a human hair.

Interesting Letters Are Welcome

We invite our members to let us have their ideas, their suggestions, their constructive criticisms . . . that's the way we can build a better and more useful Society of Engineers.

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International Missile and Spacecraft Guide, by Frederick I. Ordway, III, is Chief Space Systems, Information Branch, Nat'l. Aeronautics & Space Adm. and by Ronald C. Wakeford, staff engineer with Melpar, Ind. $25.00

Cost Engineering in the Process Industries, by Cecil Chilton, Editor-in-Chief of Chemical Engineering. $11.00

Complex Variables and the Laplace Transform for Engineers, by Wilbur R. LePage, Prof. of Electrical Engineering, Syracuse University. $12.50

Construction Estimates and Costs, by H. E. Pulver, Emeritus Prof. of Civil and Structural Engr., Univ. of Wis. $12.00 3rd Ed.

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Marketing Electrical Apparatus and Supplies, by Edwin H. Lewis. Teacher at School of Business Adminis. Univ. of Minnesota. $9.00

Modern Mathematics for the Engineer, 2nd Series, by Edwin F. Beckenbach, Prof. of Math. Univ. of Calif. $9.50

Fluorescent Lighting Manual, 3rd edition, by Charles L. Amick, Director, Research and Development, Day-Brite Lighting, Inc. $12.50

Theory of Metal Cutting, by Paul H. Black, Prof. of Mech. Engr., Ohio University. $7.50

Engineering Economics for Professional Engineers' Examinations, by Max Kurtz, consulting Structural Engineer, 1961. $6.50

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An Introduction To The Theory and Practice of Transistors, by J. R. Tillman and F. F. Roberts. $8.00

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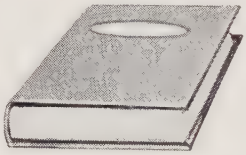

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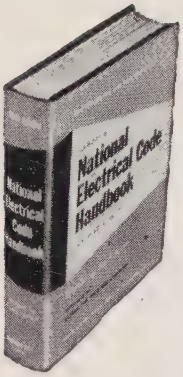

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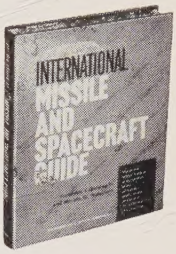

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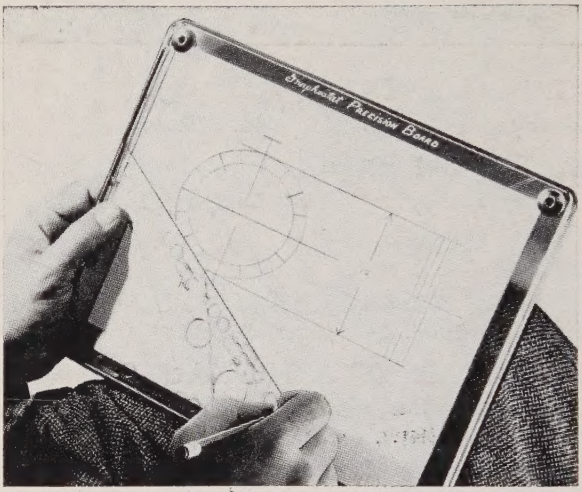

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